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ABSTRACT

This is the third of a series of three programmed instruction booklets on vectors developed by Harvard Project Physics. Separating vectors into components and obtaining a vector from its components are the topics covered. For other booklets in this series, see SE 015 549 and SE 015 550. (DT)

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SE 015 551

Project Physics **Programmed Instruction**

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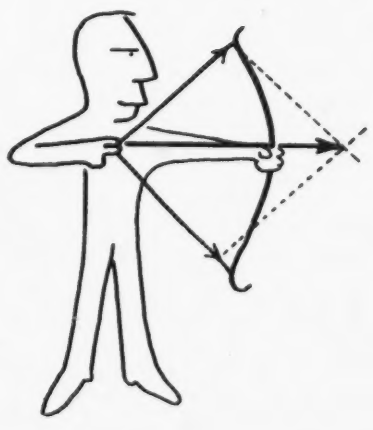
# Vectors 3



This programmed instruction booklet is the authorized interim version of one of the many instructional materials being developed by Harvard Project Physics, including text units, laboratory experiments, and teacher guides. Its development has profited from the help of many of the colleagues listed at the front of the text units.

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INTRODUCTION

You are about to use a programmed text. You should try to use this booklet where there are no distractions—a quiet classroom or a study area at home, for instance. Do not hesitate to seek help if you do not understand some problem. Programmed texts require your active participation and are designed to challenge you to some degree. Their sole purpose is to teach, not to quiz you.

# **Vectors 3** Components of Vectors

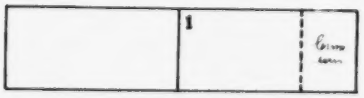
When we use a vector to represent a physical situation, we may wish to find the component of that vector in a given direction. This is Part III of the series of programmed instruction booklets on vectors. In this part, you will learn how to separate vectors into components and how to obtain a vector from its components.

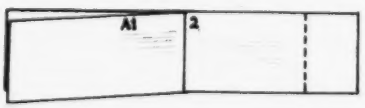
The two sample questions that follow illustrate the objectives of this part of the program, Vectors 3. If you find that you can answer these two questions correctly, you need not work through the program.

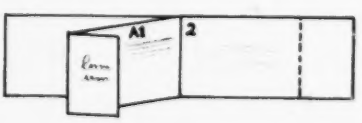
INSTRUCTIONS

1. Frames: Each frame contains a question. Answer the question by writing in the blank space next to the frame. Frames are numbered 1, 2, 3, ...

2. Answer Blocks: To find an answer to a frame, turn the page. Answer blocks are numbered A1, A2, A3, ... This booklet is designed so that you can compare your answer with the given answer by folding back the page, like this:




3. Always write your answer before you look at the given answer.

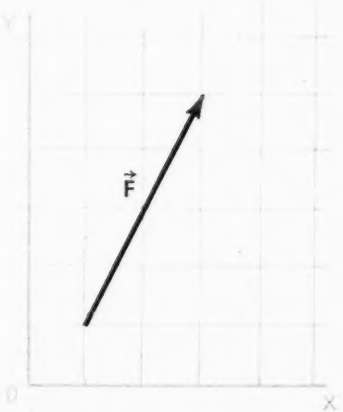
4. If you get the right answers to the sample questions, you do not have to complete the program.

**Sample Question A**

An arrow is shown that represents a force vector $\vec{F}$.

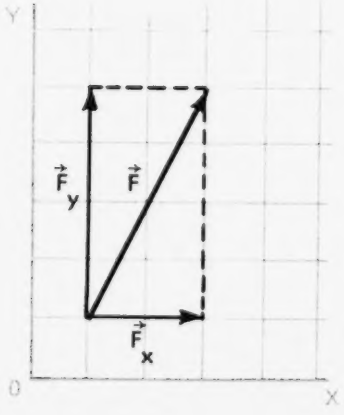
(i) Draw $\vec{F}_y$, the component of $\vec{F}$ in the y-direction.

(ii) Draw $\vec{F}_x$, the component of $\vec{F}$ in the x-direction.




**Answer Space**

**Answer A**

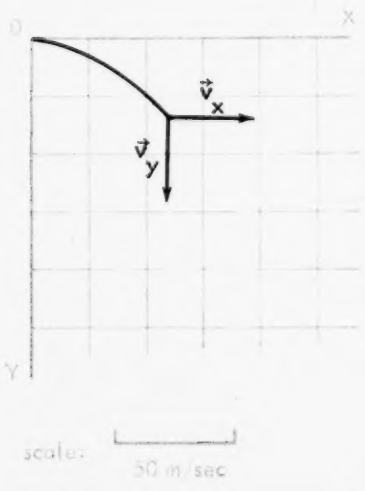


**Sample Question B**

Given $\vec{v}_x$ and $\vec{v}_y$:

(i) Construct and draw $\vec{v}$.

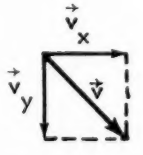
(ii) Give the direction and magnitude of $\vec{v}$.




**Answer Space**

**Answer B**

(i)



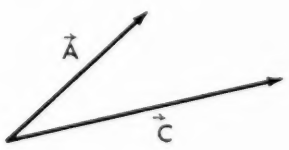

(ii) 45° below horizontal, 50 m/sec.

If your answers to the sample questions were correct, the remainder of the program is optional.

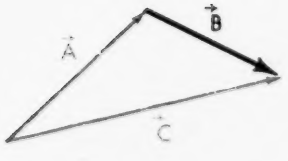
1

This is a review of material covered in previous parts of the program.

Draw the vector $\vec{B}$ that must be added to $\vec{A}$ to give $\vec{C}$.



A1



2

Draw two perpendicular vectors that add to give $\vec{F}$.

A2

Possible solutions:

Note: There are an infinite number of solutions.

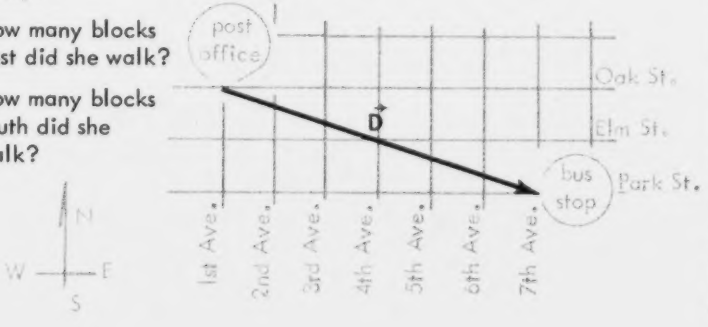
3

Martha walked from the post office to the bus stop.

Her displacement is represented by the arrow marked $\vec{D}$ on the map.

(i) How many blocks east did she walk?

(ii) How many blocks south did she walk?



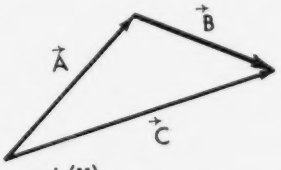
A3

(i) 6 blocks east

(ii) 2 blocks south

The diagram shows that $\vec{A} + \vec{B} = \vec{C}$.

Two vectors which add to give a third vector are called components of that vector.



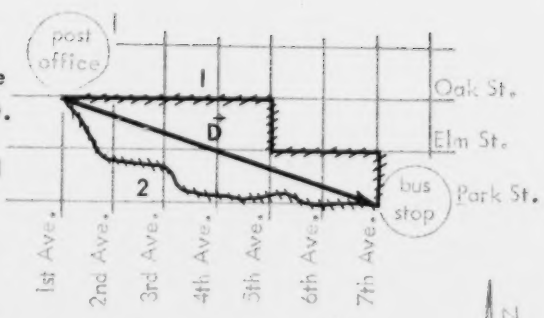

In this example, (i)_____ and (ii)_____ are components of (iii)_____.

(i) $\vec{A}$ (or $\vec{B}$)
(ii) $\vec{B}$ (or $\vec{A}$)
(iii) $\vec{C}$

**5**

The two paths marked 1 and 2 yield the same displacement vector $\vec{D}$.

Also, the easterly and southerly components must add to give $\vec{D}$ independently of the path.



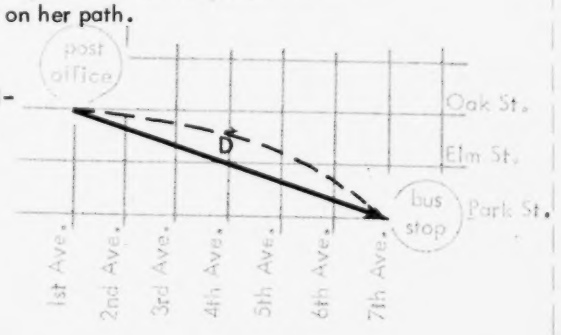
What is the magnitude of the southerly component of $\vec{D}$?

A5

2 blocks

**6**

The dashed line represents the actual path Martha took from the post office to the bus stop. Her displacement $\vec{D}$ does not depend on her path and the components of $\vec{D}$ likewise do not depend on her path.




What is the magnitude of the component of $\vec{D}$ in the easterly direction?

A6

6 blocks

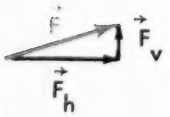
7

The vector $\vec{F}$ represents the force exerted by the rope on the wagon. We can separate the force into vertical and horizontal components.

(i) Draw the component of $\vec{F}$ in the vertical direction. Label it $\vec{F}_v$. This component tends to lift the wagon.

(ii) Draw the component of $\vec{F}$ in the horizontal direction. Label it $\vec{F}_h$. This component of the force is responsible for the motion of the wagon along the ground.

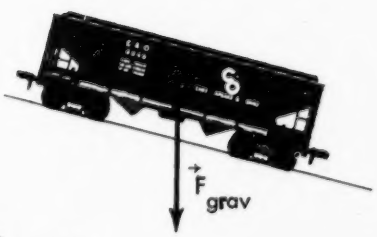
A7



8

The arrow labeled $\vec{F}_{grav}$ represents the force of gravity on this railroad hopper car.

The component of $\vec{F}_{grav}$ perpendicular to the track is balanced by the opposite force of the track on the wheels.




(i) Draw the component of $\vec{F}_{grav}$ that is perpendicular to the track. Label it $\vec{F}_{\perp}$.

(ii) Draw the component of $\vec{F}_{grav}$ that is parallel to the track. Label it $\vec{F}_{\parallel}$.

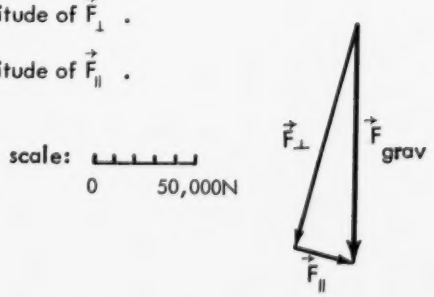
$\vec{F}_{\perp}$
$\vec{F}_{grav}$
$\vec{F}_{\parallel}$

**9**

Here is an expanded diagram from Frame 8.
The magnitude of $\vec{F}_{grav}$ is 120,000 N.

(i) Find the magnitude of $\vec{F}_{\perp}$ .

(ii) Find the magnitude of $\vec{F}_{\parallel}$ .



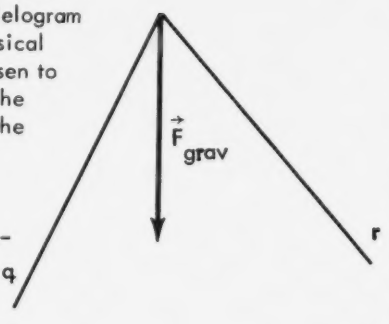
(i) 120,000 N

(ii) 30,000 N

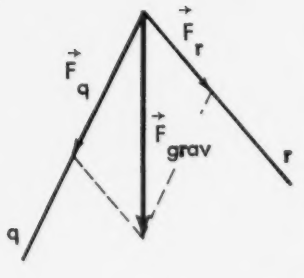
10

In general, components of a vector are constructed as the sides of a parallelogram which has the vector as the diagonal. The angle between the sides of the parallelogram may be any value; however, the physical analysis is often easiest if this is chosen to be 90°. The preceding examples of the wagon and the hopper car illustrate the usefulness of components that are at right angles.

As an example of non-perpendicular components, take the vector $\vec{F}_{grav}$ from before and resolve it into components in the q and r directions. Label the components $\vec{F}_q$ and $\vec{F}_r$.



A10

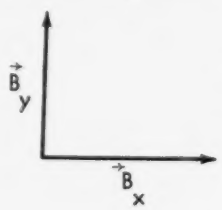


11

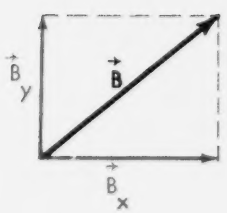
The previous frames have shown that a vector may be resolved into components along any chosen axis.

Now, given the components, it can be seen that a vector is the (vector) sum of its components.

Given $\vec{B}_x$ and $\vec{B}_y$, find $\vec{B}$.



A11



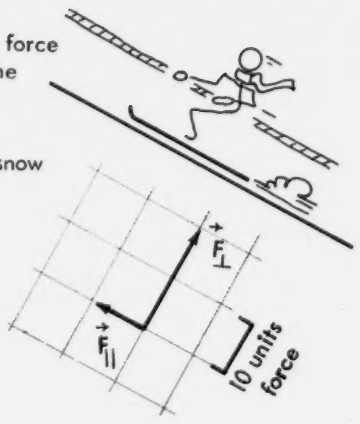
12

The ground exerts a perpendicular force $\vec{F}_{\perp}$ on the skier and the cable pulling the skier exerts a force $\vec{F}_{||}$ .

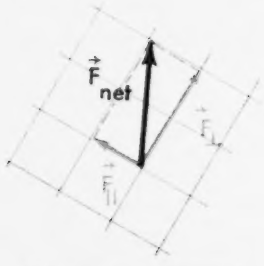
The friction between the skis and snow is negligible.

(i) Construct and draw the arrow representing the net force ($\vec{F}_{net}$ ) of the cable and the ground on the skier.

(ii) What is the direction and magnitude of the net force?



(i)

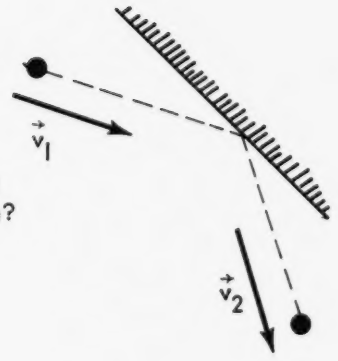



(ii) vertical (upward)
22 units of force

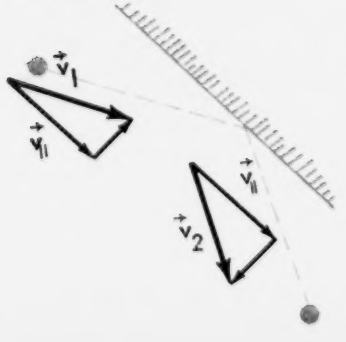
13

The diagram shows a particle striking a barrier and rebounding elastically.

Which component of velocity did not change during the interaction?



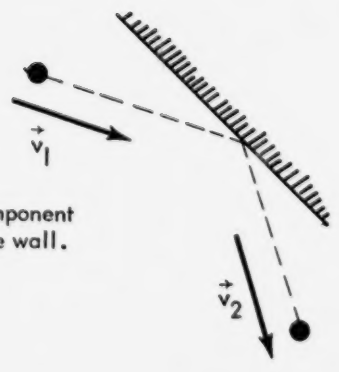
The component of velocity parallel to the wall does not change during the interaction.



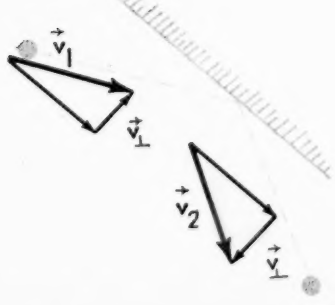
14

The component of velocity parallel to the wall does not change during the interaction.

Describe the change of the component of velocity perpendicular to the wall.



The component of velocity perpendicular to the wall reverses direction but does not change in magnitude.

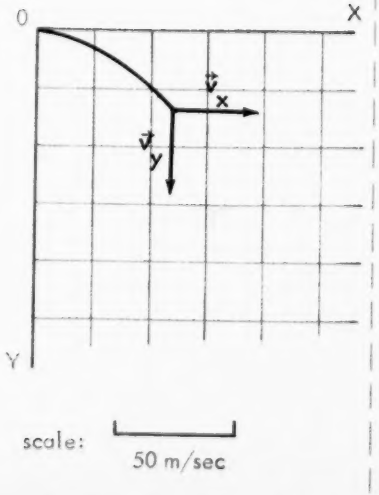


**15**

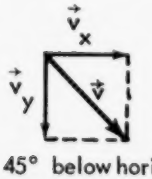
A ball has components of velocity $\vec{v}_x$ and $\vec{v}_y$ as shown in the diagram.

(i) Construct and draw $\vec{v}$.

(ii) Give the direction and magnitude of $\vec{v}$.



(i)




(ii) 45° below horizontal, 50 m/sec